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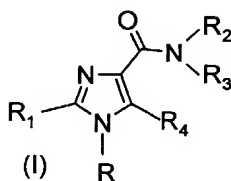
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(54) Title: 1H-IMIDAZOLE DERIVATIVES HAVING CB<sub>1</sub> AGONISTIC, CB<sub>1</sub> PARTIAL AGONISTIC OR CB<sub>1</sub>-ANTAGONISTIC ACTIVITY



(57) Abstract: AbstractThe present invention relates to a group of novel 1H-imidazole derivatives, to methods for the preparation of these compounds, and to pharmaceutical compositions containing one or more of these compounds as an active component. These 1H-imidazole derivatives are potent cannabinoid-CB<sub>1</sub> receptor agonists, partial agonists or antagonists, useful for the treatment of psychiatric and neurological disorders, as well as and other diseases involving cannabinoid neurotransmission. The compounds have the general formula (I) wherein R and R<sub>1</sub>-R<sub>4</sub> have the meanings given in the specification.



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1H-Imidazole derivatives having CB<sub>1</sub> agonistic, CB<sub>1</sub> partial agonistic or CB<sub>1</sub>-antagonistic activity

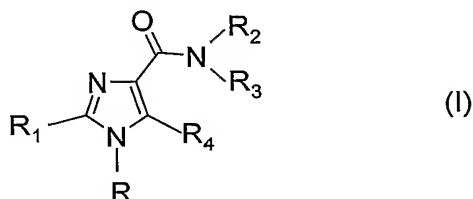
5 The present invention relates to a group of novel 1H-imidazole derivatives, to methods for the preparation of these compounds, and to pharmaceutical compositions containing one or more of these compounds as an active component.

These 1H-imidazole derivatives are potent cannabinoid-CB<sub>1</sub> receptor agonists, partial agonists or antagonists, useful for the treatment of psychiatric and neurological disorders, as well as and other diseases involving cannabinoid neurotransmission.

10 Cannabinoids are present in the Indian hemp *Cannabis sativa* and have been used as medicinal agents for centuries (Mechoulam, R. and Feigenbaum, J. J. *Prog. Med. Chem.* **1987**, 24, 159). However, only within the past ten years the research in the cannabinoid area has revealed pivotal information on cannabinoid receptors and their  
15 (endogenous) agonists and antagonists. The discovery and the subsequent cloning of two different subtypes of cannabinoid receptors (CB<sub>1</sub> and CB<sub>2</sub>) stimulated the search for novel cannabinoid receptor antagonists (Munro, S. *et al.*, *Nature* **1993**, 365, 61. Matsuda, L. A. and Bonner, T. I. *Cannabinoid Receptors*, Pertwee, R. G. Ed. **1995**, 117, Academic Press, London). In addition, pharmaceutical companies  
20 became interested in the development of cannabinoid drugs for the treatment of diseases connected with disorders of the cannabinoid system (Consroe, P. *Neurobiology of Disease* **1998**, 5, 534. Pop, E. *Curr. Opin. In CPNS Investigational Drugs* **1999**, 1, 587. Greenberg, D. A. *Drug News Perspect.* **1999**, 12, 458. Pertwee, R.G., *Progress in Neurobiology* **2001**, 63, 569). Hitherto, several CB<sub>1</sub> receptor  
25 antagonists are known. Sanofi disclosed their diarylpyrazole congeners as selective CB<sub>1</sub> receptor antagonists. A representative example is SR-141716A (Dutta, A.K. *et al.*, *Med. Chem. Res.* **1994**, 5, 54. Lan, R. *et al.*, *J. Med. Chem.* **1999**, 42, 769. Nakamura-Palacios, E. M. *et al.*, *CNS Drug Rev.* **1999**, 5, 43). CP-272871 is a pyrazole derivative, like SR141716A, but less potent and less CB<sub>1</sub> receptor subtype-  
30 selective than SR141716A (Meschler, J. P. *et al.*, *Biochem. Pharmacol.* **2000**, 60, 1315). Aminoalkylindoles have been disclosed as CB<sub>1</sub> receptor antagonists. A representative example is Iodopravadoline (AM-630), which was introduced in 1995. AM-630 is a moderately active CB<sub>1</sub> receptor antagonist, in some assays behaving as a weak partial agonist (Hosohata, K. *et al.*, *Life Sc.* **1997**, 61, PL115). Researchers  
35 from Eli Lilly described aryl-aroyl substituted benzofurans as selective CB<sub>1</sub> receptor antagonists (e.g. LY-320135) (Felder, C. C. *et al.*, *J. Pharmacol. Exp. Ther.* **1998**, 284, 291). 3-Alkyl-5,5'-diphenylimidazolidine-diones were described as cannabinoid receptor ligands, which were indicated to be cannabinoid antagonists (Kanyonyo, M. *et al.*, *Biorg. Med.Chem. Lett.* **1999**, 9, 2233). Aventis Pharma claimed  
40 diarylmethyleneazetidine analogs as CB<sub>1</sub> receptor antagonists (Mignani, S. *et al.*, Patent FR 2783246, 2000; *Chem. Abstr.* **2000**, 132, 236982). Tricyclic pyrazoles were claimed by Sanofi-Synthelabo as CB<sub>1</sub> antagonists (Barth, F. *et al.* Patent WO 0132663, 2001; *Chem. Abstr.* **2001**, 134, 340504). Interestingly, many CB<sub>1</sub> receptor

antagonists have been reported to behave as inverse agonists *in vitro* (Landsman, R. S. *et al.*, *Eur. J. Pharmacol.* **1997**, 334, R1). Pyrazole cannabinoids have also been reported as CB<sub>1</sub> receptor partial agonists showing *in vivo* cannabimimetic effects (Wiley, J. L. *et al.*, *J. Pharmacol. Exp. Ther.* **2001**, 296, 1013). A number of classes of CB<sub>1</sub> receptor agonists are known such as for example the classical cannabinoids (e.g.  $\Delta^9$ -THC), non-classical cannabinoids, aminoalkylindoles and eicosanoids (e.g. anandamide). Reviews provide a nice overview of the cannabinoid research area (Mechoulam, R. *et al.*, *Prog. Med. Chem.* **1998**, 35, 199. Lambert, D. M. *Curr. Med. Chem.* **1999**, 6, 635. Mechoulam, R. *et al.*, *Eur. J. Pharmacol.* **1998**, 359, 1. Williamson, E. M. and Evans, F. J. *Drugs* **2000**, 60, 1303. Pertwee, R. G. *Addiction Biology* **2000**, 5, 37. Robson, P. *Br. J. Psychiatry* **2001**, 178, 107. Pertwee, R. G. *Prog. Neurobiol.* **2001**, 63, 569. Goya, P. and Jagerovic, N. *Exp. Opin. Ther. Patents* **2000**, 10, 1529. Pertwee, R. G. *Gut* **2001**, 48, 859).

It has now surprisingly been found that the novel 1H-imidazole derivatives of the formula (I), prodrugs thereof and salts thereof, are potent agonists, partial agonists or antagonists on cannabinoid-CB<sub>1</sub> receptors



wherein

- R represents phenyl, thienyl, 2-pyridinyl, 3-pyridinyl, 4-pyridinyl, pyrimidinyl, pyrazinyl, pyridazinyl or triazinyl, which groups may be substituted with 1, 2, 3 or 4 substituents Y, which can be the same or different, from the group C<sub>1-3</sub>-alkyl or alkoxy, hydroxy, halogen, trifluoromethyl, trifluoromethylthio, trifluoromethoxy, nitro, amino, mono- or dialkyl (C<sub>1-2</sub>)-amino, mono- or dialkyl (C<sub>1-2</sub>)-amido, (C<sub>1-3</sub>)-alkoxycarbonyl, carboxyl, cyano, carbamoyl and acetyl, or R represents naphthyl, with the proviso that when R is 4-pyridinyl, R<sub>4</sub> represents a halogen atom or a cyano, carbamoyl, formyl, acetyl, trifluoroacetyl, fluoroacetyl, propionyl, sulfamoyl, methanesulfonyl, methylsulfonyl or branched or unbranched C<sub>1-4</sub> alkyl group, which C<sub>1-4</sub> alkyl group may be substituted with 1-3 fluoro atoms or with a bromo, chloro, iodo, cyano or hydroxy group,
- R<sub>1</sub> represents phenyl or pyridinyl, which groups may be substituted with 1-4 substituents Y, which can be the same or different, wherein Y has the above mentioned meaning, or R<sub>1</sub> represents pyrimidinyl, pyrazinyl, pyridazinyl or triazinyl, which groups may be substituted with 1-2 substituents Y, which can be the same or different or R<sub>1</sub> represents a five-membered aromatic heterocyclic ring having one or two heteroatoms from the group (N, O, S), which heteroatoms can

be the same or different, which five-membered aromatic heterocyclic ring may be substituted with 1-2 substituents Y, which can be the same or different or R<sub>1</sub> represents naphthyl,

- R<sub>2</sub> represents H, branched or unbranched C<sub>1-8</sub> alkyl, C<sub>3-8</sub> cycloalkyl, C<sub>3-8</sub> alkenyl, C<sub>5-8</sub> cycloalkenyl which groups may contain a sulfur, oxygen or nitrogen atom,
- R<sub>3</sub> represents branched or unbranched C<sub>2-8</sub> alkyl, C<sub>1-8</sub> alkoxy, C<sub>5-8</sub> cycloalkoxy, C<sub>3-8</sub> cycloalkyl, C<sub>5-10</sub> bicycloalkyl, C<sub>6-10</sub> tricycloalkyl, C<sub>3-8</sub> alkenyl, C<sub>5-8</sub> cycloalkenyl, which groups may optionally contain one or more heteroatoms from the group (O, N, S) and which groups may be substituted with a hydroxy group or 1-2 C<sub>1-3</sub> alkyl groups or 1-3 fluoro atoms, or R<sub>3</sub> represents a benzyl or phenethyl group which aromatic rings may be substituted with 1-5 substituents Z, which can be the same or different, from the group C<sub>1-3</sub>-alkyl or alkoxy, hydroxy, halogen, trifluoromethyl, trifluoromethylthio, trifluoromethoxy, nitro, amino, mono- or dialkyl (C<sub>1-2</sub>)-amino, mono- or dialkyl (C<sub>1-2</sub>)-amido, (C<sub>1-3</sub>)-alkylsulfonyl, dimethyl-sulfamido, C<sub>1-3</sub>-alkoxycarbonyl, carboxyl, trifluoromethylsulfonyl, cyano, carbamoyl, sulfamoyl and acetyl, or R<sub>3</sub> represents a phenyl or pyridinyl group, which groups are substituted with 1-4 substituents Z, wherein Z has the meaning as indicated above,

or R<sub>3</sub> represents a pyridinyl group, or R<sub>3</sub> represents a phenyl group, with the proviso that R<sub>4</sub> represents a halogen atom or a cyano, carbamoyl, formyl, acetyl, trifluoroacetyl, fluoroacetyl, propionyl, sulfamoyl, methanesulfonyl, methylsulfonyl or C<sub>1-4</sub> alkyl group, which C<sub>1-4</sub> alkyl group may be substituted with 1-3 fluoro atoms or with a bromo, chloro, iodo, cyano or hydroxy group,

or R<sub>3</sub> represents a group NR<sub>5</sub>R<sub>6</sub> with the proviso that R<sub>2</sub> represents a hydrogen atom or a methyl group, wherein

- R<sub>5</sub> and R<sub>6</sub> are the same or different and represent branched or unbranched C<sub>1-4</sub> alkyl, or R<sub>5</sub> and R<sub>6</sub> - together with the nitrogen atom to which they are bonded - form a saturated or unsaturated, monocyclic or bicyclic heterocyclic group having 4 to 10 ring atoms which heterocyclic group contains one or two heteroatoms from the group (N, O, S), which heteroatoms can be the same or different, which heterocyclic group may be substituted with a C<sub>1-3</sub> alkyl group or a hydroxy group, or R<sub>2</sub> and R<sub>3</sub> - together with the nitrogen atom to which they are bonded - form a saturated or unsaturated heterocyclic group having 4 to 10 ring atoms which heterocyclic group contains one or two heteroatoms from the group (N, O, S), which heteroatoms can be the same or different, which heterocyclic group may be substituted with a C<sub>1-3</sub> alkyl group or a hydroxy group,
- R<sub>4</sub> represents a hydrogen or halogen atom or a cyano, carbamoyl, formyl, acetyl, trifluoroacetyl, fluoroacetyl, propionyl, sulfamoyl, methanesulfonyl, methylsulfonyl or branched or unbranched C<sub>1-4</sub> alkyl group, which C<sub>1-4</sub> alkyl group may be substituted with 1-3 fluoro atoms or with a bromo, chloro, iodo, cyano or a hydroxy group,

Due to the potent CB<sub>1</sub> agonistic, partial agonistic or antagonistic activity the compounds according to the invention are suitable for use in the treatment of psychiatric disorders such as psychosis, anxiety, depression, attention deficits, memory disorders, cognitive disorders, appetite disorders, obesity, addiction, 5 appetite, drug dependence and neurological disorders such as neurodegenerative disorders, dementia, dystonia, muscle spasticity, tremor, epilepsy, multiple sclerosis, traumatic brain injury, stroke, Parkinson's disease, Alzheimer's disease, epilepsy, Huntington's disease, Tourette's syndrome, cerebral ischaemia, cerebral apoplexy, craniocerebral trauma, stroke, spinal cord injury, neuroinflammatory disorders, 10 plaque sclerosis, viral encephalitis, demyelination related disorders, as well as for the treatment of pain disorders, including neuropathic pain disorders, and other diseases involving cannabinoid neurotransmission, including the treatment of septic shock, glaucoma, diabetes, cancer, emesis, nausea, gastrointestinal disorders, gastric ulcers, diarrhoea and cardiovascular disorders.

15 The affinity of the compounds of the invention for cannabinoid CB<sub>1</sub> receptors was determined using membrane preparations of Chinese hamster ovary (CHO) cells in which the human cannabinoid CB<sub>1</sub> receptor is stably transfected in conjunction with [<sup>3</sup>H]CP-55,940 as radioligand. After incubation of a freshly prepared cell membrane 20 preparation with the [<sup>3</sup>H]-ligand, with or without addition of compounds of the invention, separation of bound and free ligand was performed by filtration over glassfiber filters. Radioactivity on the filter was measured by liquid scintillation counting.

25 The cannabinoid CB<sub>1</sub> antagonistic activity of compounds of the invention was determined by functional studies using CHO cells in which human cannabinoid CB<sub>1</sub> receptors are stably expressed. Adenylyl cyclase was stimulated using forskolin and measured by quantifying the amount of accumulated cyclic AMP. Concomitant 30 activation of CB<sub>1</sub> receptors by CB<sub>1</sub> receptor agonists (*e.g.* CP-55,940 or (R)-WIN-55,212-2) can attenuate the forskolin-induced accumulation of cAMP in a concentration-dependent manner. This CB<sub>1</sub> receptor-mediated response can be antagonized by CB<sub>1</sub> receptor antagonists such as the compounds of the invention.

35 Cannabinoid agonistic or partial agonistic activity of compounds of the invention can be determined according to published methods, such as assessment of *in vivo* cannabimimetic effects (Wiley, J. L. *et al.*, *J. Pharmacol. Exp. Ther.* **2001**, 296, 1013).

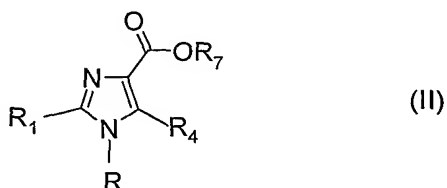
40 The invention relates both to racemates, mixtures of diastereomers and the individual stereoisomers of the compounds having formula (I).

The compounds of the invention can be brought into forms suitable for administration by means of usual processes using auxiliary substances and/or liquid or solid carrier materials.

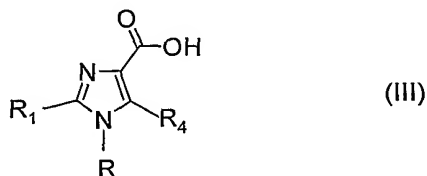
5 Suitable synthetic routes for the compounds of the invention are the following:

### Synthetic route A

10 Step 1: ester hydrolysis of a compound having formula (II) wherein  $R_7$  represents a branched or unbranched alkyl group ( $C_{1-4}$ ) or benzyl group



This reaction gives a compound having formula (III)



15

wherein  $R$ ,  $R_1$  and  $R_4$  have the meanings as described above.

Intermediates having formula (II), wherein  $R_7$  represents a branched or unbranched alkyl group ( $C_{1-4}$ ) or benzyl group can be obtained according to methods known, for example:

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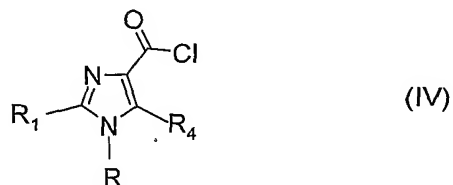
- a) I. K. Khanna et al., *J. Med. Chem.* **2000**, *43*, 3168-3185
- b) N. Kudo et al., *Chem. Pharm. Bull.* **1999**, *47*, 857-868
- c) K. Tsuji et al., *Chem. Pharm. Bull.* **1997**, *45*, 987-995
- d) I. K. Khanna et al., *J. Med. Chem.* **1997**, *40*, 1634-1647
- 25 e) M. Guillemet et al., *Tetrahedron Lett.* **1995**, *36*, 547-548

30

Step 2: reaction of a compound having formula (III) with a compound having formula  $R_2R_3NH$  wherein  $R_2$  and  $R_3$  have the meanings as described above *via* activating and coupling methods such as formation of an active ester, or in the presence of a coupling reagent such as DCC, HBTU, BOP or similar reagents. This reaction gives a desired 1H-imidazole derivative having formula (I).

(For more information on activating and coupling methods see: M. Bodanszky and A. Bodanszky: *The Practice of Peptide Synthesis*, Springer-Verlag, New York, 1994; ISBN: 0-387-57505-7).

Alternatively, a compound having formula (III) is reacted with a halogenating agent, for example thionyl chloride ( $\text{SOCl}_2$ ). This reaction gives the corresponding carbonyl chloride (IV).

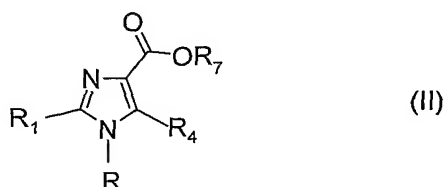


Reaction of a compound having formula (IV) with a compound having formula  $\text{R}_2\text{R}_3\text{NH}$  wherein  $\text{R}_2$  and  $\text{R}_3$  have the meanings as described above, yields a 1H-imidazole derivative having formula (I). This reaction is preferably carried out in the presence of an organic base such as for example diisopropylethylamine (DIPEA) or triethylamine.

Alternatively, a compound having formula (II) is reacted in an amidation reaction with a compound having formula  $\text{R}_2\text{R}_3\text{NH}$  wherein  $\text{R}_2$  and  $\text{R}_3$  have the meanings as described above to give a 1H-imidazole derivative having formula (I).

### Synthetic route B

Reaction of a compound having formula (II), wherein  $\text{R}_4$  represents hydrogen and wherein  $\text{R}$ ,  $\text{R}_1$  and  $\text{R}_7$  have the meanings as described above for compound (II), with a compound having general formula  $\text{R}_4'\text{-X}$ , wherein  $\text{X}$  represents a leaving group and  $\text{R}_4'$  represents a  $\text{C}_{1-4}$  alkyl group, which alkyl group may be substituted with 1-3 fluoro atoms or wherein  $\text{R}_4'$  represents a cyano, formyl, acetyl, trifluoroacetyl, fluoroacetyl, methylsulfanyl or propionyl moiety, or a halogen atom. This reaction is carried out in the presence of a strong non-nucleophilic base such as lithium diisopropylamide (LDA), preferably under anhydrous conditions in an inert organic solvent, for example tetrahydrofuran, and yields a compound having formula (II)



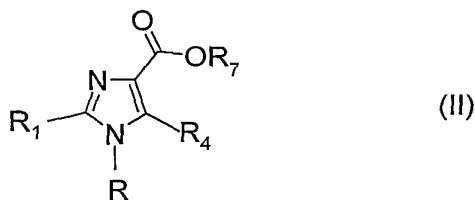
wherein  $\text{R}$ ,  $\text{R}_1$  and  $\text{R}_7$  have the meanings as described hereinabove and  $\text{R}_4$  represents a  $\text{C}_{1-4}$  alkyl group, which alkyl group may be substituted with 1-3 fluoro atoms or wherein  $\text{R}_4$  represents a cyano, formyl, acetyl, trifluoroacetyl, fluoroacetyl, methylsulfanyl or propionyl group, or a halogen atom.

Compounds of general formula (II) which have been obtained according to synthesis route B can be converted to compounds of general formula (I) analogously to the procedures described in synthesis route A, step 1 of route A or step 2 of route A (see  
5 above).

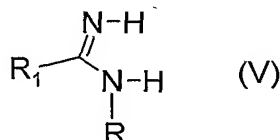


**Synthetic route C**

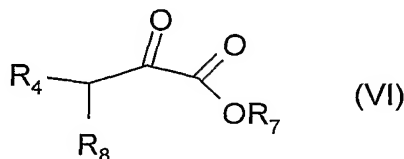
Compounds having formula (II)



wherein  $R_4$  represents a branched or unbranched  $C_{1-4}$  alkyl group, which  $C_{1-4}$  alkyl group may be substituted with 1-3 fluoro substituents and wherein R,  $R_1$  have the meanings given above and  $R_7$  represents a branched or unbranched alkyl group ( $C_{1-4}$ ) or benzyl group can be synthesized by reacting a compound having formula (V) or its tautomer



wherein R and  $R_1$  have the meanings given above, with a compound having formula (VI)



wherein  $R_4$  represents a branched or unbranched  $C_{1-4}$  alkyl group, which  $C_{1-4}$  alkyl group may be substituted with 1-3 fluoro atoms and  $R_8$  represents a leaving group, for example a bromo substituent, and  $R_7$  represents a branched or unbranched alkyl group ( $C_{1-4}$ ) or benzyl group. The reaction is preferably carried out in an organic solvent, for example in 2-propanol or in N-methyl-2-pyrrolidinone (NMP). The addition of an acid like trifluoroacetic acid (TFA) during the reaction may enhance the formation of the compounds having formula (II).

(For more information on the leaving group concept see: M. B. Smith and J. March: *Advanced organic chemistry*, p. 275, 5<sup>th</sup> ed., (2001) John Wiley & Sons, New York, ISBN: 0-471-58589-0).

Compounds of general formula (II) which have been obtained according to synthesis route C can be converted to compounds of general formula (I) analogously to the

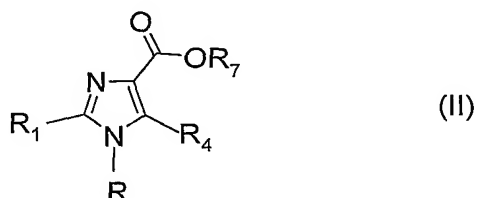
procedures described in synthesis route A, step 1 of route A or step 2 of route A (see above).

Compounds of the invention having formula (VI) can be obtained according to methods known, for example: P. Seifert *et al.*, *Helv. Chim. Acta*, **1950**, 33, 725.

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### Synthetic route D

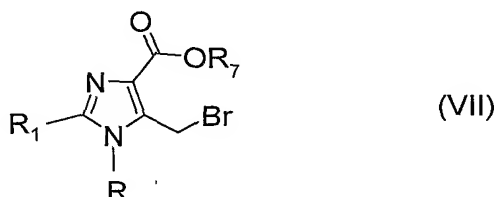
Reaction of a compound having formula (II)



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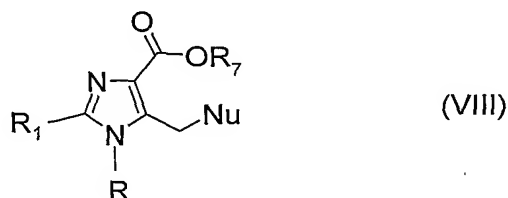
wherein  $R_4$  represents a methyl group and R,  $R_1$  have the meanings given above and  $R_7$  represents a branched or unbranched alkyl group ( $C_{1-4}$ ) or benzyl group with a regioselective brominating compound such as N-bromo-succinimide (NBS) in an organic solvent such as  $CCl_4$  in the presence of a free-radical initiator like dibenzoyl peroxide gives a compound of formula (VII)

15



wherein R,  $R_1$  and  $R_7$  have the meanings given above. Reaction of a compound having formula (VII) (*analogous to the method described in Mathews, W.B. et al., J. Label. Compds. Radiopharm., 1999, 42, 589*) with for example KCl, KI, KF or KCN gives a compound of formula (VIII)

20



25

wherein R,  $R_1$  and  $R_7$  have the meanings given hereinabove and Nu represents a chloro, iodo, fluoro or cyano group. The reaction is preferably carried out in the presence of a weak base like  $NaHCO_3$  or in the presence of a crown ether or a cryptand. (*For more information on crown ethers and cryptands see: M. B. Smith and*

30

*J. March: Advanced organic chemistry, p. 105, 5<sup>th</sup> ed., (2001) John Wiley & Sons, New York, ISBN: 0-471-58589-0).*

5 Compounds of general formula (VII) or (VIII) which have been obtained according to synthesis route D can be converted to compounds of general formula (I) analogously to the procedures described in synthesis route A, step 1 of route A, or step 2 of route A (see above).

#### Example 1

10 **Part A:** To a 1M solution of sodium bis(trimethylsilyl) amide in THF (70 mL) is added dropwise a solution of 4-chloroaniline (8.86 gram, 69.5 mmol) in anhydrous THF in a nitrogen atmosphere. After the mixture is stirred for 20 minutes a solution of 2,4-dichlorobenzonitrile (12 gram, 70 mmol) in THF is added. The resulting mixture is stirred overnight, poured into ice-water (400 mL) and extracted with dichloromethane,  
15 dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo* to give a yellow oil (15.7 gram). Crystallisation from a dichloromethane/heptane mixture, and subsequent washing with methyl-t-butyl ether gives N-(4-chlorophenyl)-2,4-dichlorobenzenecarboxamidine (8.66 gram, 42 % yield) as a yellow solid. Melting point (MP): 93-95 °C.

20 Analogously was prepared:

– N-(4-bromophenyl)-2,4-dichlorobenzenecarboxamidine. MP: 117-119 °C.

**Part B:** A mixture of N-(4-chlorophenyl)-2,4-dichlorobenzenecarboxamidine (2.00 gram, 6.68 mmol), ethyl 3-bromo-2-oxopropanoate (2.65 gram, 13.6 mmol) and NaHCO<sub>3</sub> (1.12 gram, 13.3 mmol) in 2-propanol is stirred at reflux temperature for 20 hours. After cooling to room temperature the mixture is concentrated *in vacuo* and the residue suspended in dichloromethane, washed with water (3 x 50 mL) and brine (3 x 50 mL). The aqueous layers are extracted with dichloromethane. The combined  
30 organic layers are dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo* to afford crude brown product (2.0 gram). This product is further purified by column chromatography (silicagel, heptane/EtOAc = 90/10 (v/v)) to yield ethyl 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate (0.759 gram, 29 % yield) as a yellow oil which slowly solidifies on standing. Melting point: 150-152 °C; MS: 395 (MH<sup>+</sup>). <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>): δ 7.91 (s, 1H), 7.49 (dd, J = 8 Hz, J = 2 Hz, 1H), 7.29-7.36 (m, 4H), 7.07 (dt, J = 8 Hz, J = 2 Hz, 2H), 4.44 (q, J = 7 Hz, 2H), 1.42 (t, J = 7 Hz, 3H).

**Part C:** Ethyl 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate (0.810 gram, 2.06 mmol) and LiOH (0.173 g, 7.20 mmol) are dissolved in a H<sub>2</sub>O/THF (20 mL/20 mL) mixture and stirred at 50 °C for 16 hours. The mixture is concentrated  
40 *in vacuo* to give 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylic acid. Thionyl chloride (60 mL) is added and the mixture is heated at reflux

temperature for 1 hour and concentrated *in vacuo* to give crude 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carbonyl chloride.

**Part D:** Crude 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carbonyl chloride (919 mg, ~2.39 mmol), 1-aminopiperidine (0.469 g, 4.69 mmol) and triethylamine (0.363 g, 3.59 mmol) are dissolved in dichloromethane and stirred for one hour at room temperature. The mixture is washed with a saturated aqueous NaHCO<sub>3</sub> solution (3 x 20 mL), dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo* and further purified by column chromatography (ethyl acetate, silicagel) to give 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide (356 mg, 26 % yield (based on ethyl 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate). Mass Spectrometry (MS): 449.

Analogously were prepared:

2. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-N-(pyrrolidin-1-yl)-1H-imidazole-4-carboxamide; MS: 435.
3. N-(t-Butoxy)-1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxamide; MS: 438.
4. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-N-phenyl-1H-imidazole-4-carboxamide; MS: 442.
5. 1-(4-Chlorophenyl)-N-cyclohexyl-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxamide; MS: 448.
6. N-(Benzyl)-1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-N-methyl-1H-imidazole-4-carboxamide; MS: 470.
7. 1-[1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-4-(1H-imidazolyl)carbonyl]hexahydro-1H-azepine; MS: 448.
8. 2-(4-Chlorophenyl)-1-(2,4-dichlorophenyl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide (prepared from 2,4-dichloroaniline and 4-chlorobenzo-nitrile); MS: 449.
9. N-(t-Butoxy)-2-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-1H-imidazole-4-carboxamide (prepared from 2,4-dichloroaniline and 4-chlorobenzonitrile); MS: 438.

#### Example 10

**Part A:** Diisopropylamine (2.30 gram, 22.8 mmol) is added dropwise to anhydrous THF (100 mL) in a nitrogen atmosphere at 0 °C. n-BuLi is added dropwise (7.34 mL, 2.5 M solution in hexane, 18.4 mmol). The resulting solution is cooled to - 78 °C. A solution of ethyl 2-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate (6.0 gram, 15.2 mmol) in anhydrous THF is added dropwise. The colour of the mixture changes from yellow to purple brown. The stirred mixture is warmed to - 40 °C and cooled to - 78 °C and allowed to stand for 30 minutes. Methyl iodide (6.44 gram, 45.4 mmol) is added dropwise and the resulting solution is stirred for 30

min at - 78 °C and then allowed to attain room temperature. The resulting solution is quenched with an aqueous NH<sub>4</sub>Cl solution, diethyl ether is added and the organic layer is dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo* to give an oil (6.4 gram). This oil is purified by column chromatography (toluene/EtOAc = 10/2 (v/v), silicagel) to give pure ethyl 2-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxylate (5.3 gram, 85 % yield) as a yellow oil.

**Part B:** Ethyl 2-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxylate (0.250 gram, 0.61 mmol) and LiOH (0.052 gram, 2.17 mmol) are dissolved in H<sub>2</sub>O/THF (1:1 (v/v); 50 mL) and stirred at 50 °C for one hour. The mixture is concentrated to give crude 2-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxylic acid. To this mixture is added SOCl<sub>2</sub> (50 mL) and the resulting mixture is heated at reflux temperature for 1 hour. The mixture is concentrated to give 2-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carbonyl chloride.

**Part C:** 2-(4-Chlorophenyl)-1-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carbonyl chloride (1.5 gram, 3.75 mmol), 1-aminopiperidine (0.725 gram, 7.25 mmol) and triethylamine (0.549 gram, 5.44 mmol) are dissolved in dichloromethane and stirred for one hour at room temperature. The mixture is washed with a saturated aqueous NaHCO<sub>3</sub> solution, dried over Na<sub>2</sub>SO<sub>4</sub> and concentrated *in vacuo* and further purified by column chromatography (heptane/ethyl acetate = 1/1 (v/v), silicagel) to give 2-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-5-methyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide (0.220 gram, 13 % yield) as a white foam. MS: 463.

Analogously were prepared:

11. N-(t-Butoxy)-2-(4-chlorophenyl)-1-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxamide: MS: 452.

12. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide: MS: 463; Melting point: 165-167 °C.

13. N-(t-Butoxy)-2-(2,4-dichlorophenyl)-1-(4-chlorophenyl)-5-methyl-1H-imidazole-4-carboxamide: MS: 452.

14. N-(t-Butoxy)-1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-5-ethyl-1H-imidazole-4-carboxamide: Amorphous. MS: 468.

15. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-ethyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide: MS: 477.

16. 1-(4-Bromophenyl)-N-(t-butoxy)-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxamide: Amorphous.

17. 1-(4-Bromophenyl)-2-(2,4-dichlorophenyl)-5-methyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide: MP: > 204 °C. TLC (Silicagel, EtOAc) R<sub>f</sub> = 0.3.

18. 1-(4-Bromophenyl)-N-(t-butoxy)-2-(2,4-dichlorophenyl)-5-ethyl-1H-imidazole-4-carboxamide: Amorphous. TLC (Silicagel, CH<sub>2</sub>Cl<sub>2</sub>/acetone = 9/1 (v/v)) R<sub>f</sub> = 0.45.

19. 1-(4-Bromophenyl)-2-(2,4-dichlorophenyl)-5-ethyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide: MP: > 140 °C. TLC (Silicagel, EtOAc)  $R_f$  = 0.4.
20. 1-(4-Bromophenyl)-N-cyclohexyl-2-(2,4-dichlorophenyl)-5-ethyl-1H-imidazole-4-carboxamide: Melting point > 135-140 °C.
- 5 21. 1-(4-Bromophenyl)-2-(2,4-dichlorophenyl)-5-ethyl-N-(n-pentyl)-1H-imidazole-4-carboxamide: Syrup. TLC (Silicagel,  $\text{CH}_2\text{Cl}_2$ /acetone = 19/1 (v/v))  $R_f$  = 0.4.

#### Example 22

**Part A:** To a stirred solution of ethyl 1-(4-bromophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate (6.10 gram, 0.0139 mol) in THF (70 mL) is added LiOH (0.67 gram, 0.0278 mol) and water (70 mL). The resulting mixture is stirred for 16 hours at 50 °C to give a clear solution. After cooling to room temperature, HCl (1N solution, 28 mL) is added to give an oily precipitate which completely solidifies on continued stirring and addition of water (70 mL). The precipitate is collected by filtration, washed with water and dried *in vacuo* to give 1-(4-bromophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylic acid (4.92 gram, 86 % yield). Melting point: 138-142 °C.

**Part B:** To a stirred suspension of 1-(4-bromophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylic acid (1.23 gram, 2.99 mmol) in dry acetonitrile (40 mL) is successively added diisopropylethylamine (DIPEA) (1.15 mL, 6.6 mmol), O-benzotriazol-1-yl-N, N', N'-tetramethyluronium hexafluorophosphate (HBTU) (1.36 gram, 3.6 mmol) and 1-aminopiperidine (0.39 mL, 3.6 mmol). After stirring for 16 hours, the resulting mixture is concentrated *in vacuo*. The residue is dissolved in ethylacetate and an aqueous  $\text{NaHCO}_3$  solution is added. The ethylacetate layer is collected, washed with water and brine, dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo* to give a crude solid. This solid is further purified by recrystallisation from acetonitrile to give 1-(4-bromophenyl)-2-(2,4-dichlorophenyl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide (830 mg, 56 % yield). Melting point: 219-221 °C.

30 Analogously were prepared:

23. N-(t-Butoxy)-1-(4-bromophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxamide. Amorphous. TLC (Silicagel,  $\text{Et}_2\text{O}$ )  $R_f$  = 0.3.
24. 1-(4-Bromophenyl)-2-(2,4-dichlorophenyl)-N-(pyrrolidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 238-240 °C.
- 35 25. N-(Azepan-1-yl)-1-(4-bromophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxamide. Melting point: 201-204 °C.
26. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-N-(hexahydrocyclopenta[c]pyrrol-2(1H)-yl)-1H-imidazole-4-carboxamide. MS: 475.
- 40 27. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-N-(4-fluorobenzyl)-1H-imidazole-4-carboxamide. MS: 474.

28. 1-(4-Chlorophenyl)-2-(2-methoxy-4-chlorophenyl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 220 °C.
29. 1-(4-Chlorophenyl)-N-cyclohexyl-2-(2-methoxy-4-chlorophenyl)-1H-imidazole-4-carboxamide. Melting point: 177-179 °C.
- 5 30. 1-(4-Chlorophenyl)-2-(2-fluoro-4-chlorophenyl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 217-218 °C.
31. 2-(2,4-Dichlorophenyl)-1-(4-fluorophenyl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 175-176 °C.
32. N-Cyclohexyl-2-(2,4-dichlorophenyl)-1-(4-fluorophenyl)-1H-imidazole-4-carboxamide. Melting point: 184-185 °C.
- 10 33. N-Cyclohexyl-2-(2-fluoro-4-chlorophenyl)-1-(4-chlorophenyl)-1H-imidazole-4-carboxamide. Melting point: 157-159 °C.
34. 1-(4-Chlorophenyl)-2-(2-methoxy-4-chlorophenyl)-N-(n-pentyl)-1H-imidazole-4-carboxamide. Melting point: 115 °C.
- 15 35. 2-(2,4-Dichlorophenyl)-1-(4-methoxyphenyl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 178-179 °C.
36. N-Cyclohexyl-2-(2,4-dichlorophenyl)-1-(4-methoxyphenyl)-1H-imidazole-4-carboxamide. Melting point: 175-176 °C.
37. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-N,N-diethyl-1H-imidazole-4-carboxamide. Melting point: 177-179 °C.
- 20 38. 1-(4-Chlorophenyl)-N-cyclohexyl-2-(2-trifluoromethyl-4-chlorophenyl)-1H-imidazole-4-carboxamide. Melting point: 172 °C.
39. 1-(4-Chlorophenyl)-N-(piperidin-1-yl)-2-(2-trifluoromethyl-4-chlorophenyl)-1H-imidazole-4-carboxamide. Melting point: 219 °C.
- 25 40. N-(1-Adamantyl)-1-(4-chlorophenyl)-2-(2-trifluoromethyl-4-chlorophenyl)-1H-imidazole-4-carboxamide. Melting point: 288 °C.
41. 1-(4-Chlorophenyl)-N-(2,2,2-trifluoroethyl)-2-(2-trifluoromethyl-4-chlorophenyl)-1H-imidazole-4-carboxamide. Melting point: 149 °C.
42. 2-(2,4-Dichlorophenyl)-1-(pyridin-3-yl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 165-170 °C.
- 30 43. N-Cyclohexyl-2-(2,4-dichlorophenyl)-1-(pyridin-3-yl)-1H-imidazole-4-carboxamide. Melting point: 195 °C.
44. 2-(2,4-Dichlorophenyl)-1-(pyridin-3-yl)-N-(n-pentyl)-1H-imidazole-4-carboxamide. Melting point: 117 °C.
- 35

#### Example 45

**Part A:** 2,4-Dichlorobenzoyl chloride (40.0 g, 0.19 mol) is dissolved in tetrahydrofuran (1 L). To the resulting stirred solution is successively added diisopropylethylamine (DIPEA) (73.4 mL, 2.2 molar equivalent) and 4-(trifluoromethyl)phenylamine (30.7 g, 0.19 mol). After one hour the mixture is concentrated *in vacuo* to give an oil. This oil is crystallised from ethanol to give pure 2,4-dichloro-N-(4-(trifluoromethyl)phenyl)benzamide (53.2 g, 83 % yield). <sup>1</sup>H-NMR

40

(200 MHz, DMSO- $d_6$ ):  $\delta$  10.90 (br s, 1H), 7.91 (br d,  $J$  = 8 Hz, 2H), 7.63-7.77 (m, 4H), 7.57 (dt,  $J$  = 8 Hz,  $J$  = 2 Hz, 1H).

**Part B:** 2,4-Dichloro-N-(4-(trifluoromethyl)phenyl)benzamide (19.0 g, 0.057 mol) is dissolved in benzene (150 mL) and  $\text{PCl}_5$  (13.0 g, 1.1 molar equivalent) is added. The resulting mixture is heated at reflux temperature for two hours, allowed to attain room temperature and concentrated *in vacuo* to give a residue. The residue is dissolved in anhydrous THF, cooled to 0 °C and transferred into an autoclave. Excess  $\text{NH}_3$  is quickly added from a lecture bottle and the mixture is stirred at room temperature for 50 hours. A mixture of ethylacetate and aqueous  $\text{NaHCO}_3$  is added. The ethylacetate layer is collected, dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo*. The resulting oil is purified by column chromatography (diethyl ether/petroleum ether = 1/1 (v/v), silicagel) to give pure 2,4-dichloro-N-(4-(trifluoromethyl)phenyl)benzenecarboxamidine (16.9 g, 89 % yield). Melting point: 108-109 °C.

**Part C:** 2,4-Dichloro-N-(4-(trifluoromethyl)phenyl)benzenecarboxamidine (15.0 g, 0.0450 mol) is dissolved in 2-propanol and ethyl 3-bromo-2-oxobutanoate (20.8 g, 2 molar equivalent) and  $\text{NaHCO}_3$  are successively added. The resulting mixture is heated at reflux temperature for 40 hours and allowed to attain room temperature. The 2-propanol is removed *in vacuo*, ethyl acetate is added to the residue and the resulting organic layer is washed with  $\text{NaHCO}_3$  (5 % aqueous solution). The ethylacetate layer is collected, dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo*. The resulting oil is purified by column chromatography (diethyl ether/petroleum ether = 1/3 (v/v), silicagel) and further purified by crystallisation from cyclohexane to give ethyl 2-(2,4-dichlorophenyl)-5-methyl-1-(4-(trifluoromethyl)phenyl)-1H-imidazole-4-carboxylate (10.45 g, 52 % yield) as a yellow solid. Melting point: 160-162 °C.

**Part D:** The formed ethyl 2-(2,4-dichlorophenyl)-5-methyl-1-(4-(trifluoromethyl)phenyl)-1H-imidazole-4-carboxylate is converted to 2-(2,4-dichlorophenyl)-5-methyl-1-(4-(trifluoromethyl)phenyl)-1H-imidazole-4-carboxylic acid (melting point: 224-226 °C), which carboxylic acid is converted to 2-(2,4-dichlorophenyl)-5-methyl-N-(piperidin-1-yl)-1-(4-(trifluoromethyl)phenyl)-1H-imidazole-4-carboxamide (melting point: 173-174 °C) according to the procedure described in example 22 above.

Analogously were prepared

46. 2-(2,4-dichlorophenyl)-N-(piperidin-1-yl)-1-(4-(trifluoromethyl)phenyl)-1H-imidazole-4-carboxamide. Melting point: >200 °C (decomposition).

47. N-Cyclohexyl-2-(2,4-dichlorophenyl)-5-methyl-1-(4-(trifluoromethyl)phenyl)-1H-imidazole-4-carboxamide. Melting point: 178-179 °C.

48. N-Cyclohexyl-2-(2,4-dichlorophenyl)-1-(4-(trifluoromethyl)phenyl)-1H-imidazole-4-carboxamide. Melting point: 199-200 °C.

#### Example 49

**Part A:** N-(4-methoxyphenyl)-2,4-dichlorobenzenecarboxamidine (15.0 gram, 50.8 mmol) is dissolved in 2-propanol and ethyl 3-bromo-2-oxobutanoate (23.5 g, 2 molar



equivalents) and  $\text{NaHCO}_3$  (8.5 gram, 2 molar equivalents) are successively added. The resulting mixture is heated at reflux temperature for 40 hours and allowed to attain room temperature. The 2-propanol is removed *in vacuo*, ethyl acetate is added to the residue and the resulting organic layer is washed with  $\text{NaHCO}_3$  (5 % aqueous solution). The ethylacetate layer is collected, dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo*. The resulting oil is purified by column chromatography (diethyl ether/petroleum ether = 1/3 (v/v), silicagel) to give ethyl 2-(2,4-dichlorophenyl)-5-methyl-1-(4-methoxy-phenyl)-1H-imidazole-4-carboxylate (8.61 g, 42 % yield) as a solid.  $^1\text{H-NMR}$  (200 MHz,  $\text{CDCl}_3$ ):  $\delta$  7.33 (d,  $J$  = 8 Hz, 1H), 7.27 (d,  $J$  = 2 Hz, 1H), 7.18 (dd,  $J$  = 8 Hz,  $J$  = 2 Hz, 1H), 7.03 (dt,  $J$  = 8 Hz,  $J$  = 2 Hz, 2H), 6.85 (dt,  $J$  = 8 Hz,  $J$  = 2 Hz, 2H), 4.42 (q,  $J$  = 7 Hz, 2H), 3.80 (s, 3H), 2.43 (s, 3H), 1.43 (t,  $J$  = 7 Hz, 3H).

**Part B:** To a stirred solution of ethyl 2-(2,4-dichlorophenyl)-5-methyl-1-(4-methoxyphenyl)-1H-imidazole-4-carboxylate (8.00 gram, 0.0198 mol) in THF (80 mL) is added LiOH (0.59 gram, 2 molar equivalents) and water (80 mL). The resulting mixture is stirred for 16 hours at 80 °C. After cooling to room temperature, HCl (2N solution, 12.3 mL) is added to give an oily precipitate. After addition of water and extraction with ethylacetate, the ethylacetate layer is collected, dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo*. The residue is crystallised from diisopropyl ether and dried to give 2-(2,4-dichlorophenyl)-5-methyl-1-(4-methoxyphenyl)-1H-imidazole-4-carboxylic acid (4.04 gram, 87 % yield) as a pale grey solid. Melting point: 189-191 °C.

**Part C:** To 2-(2,4-dichlorophenyl)-5-methyl-1-(4-methoxyphenyl)-1H-imidazole-4-carboxylic acid (1.00 gram, 2.65 mmol) in dry acetonitrile (25 mL) is successively added diisopropylethylamine (DIPEA) (1.02 mL, 2.2 molar equivalents), O-benzotriazol-1-yl-N, N', N'-tetramethyluronium hexafluoro-phosphate (HBTU) (1.21 gram, 1.2 molar equivalents) and the resulting solution is stirred for 15 minutes. Cyclohexylamine (0.36 mL, 1.2 molar equivalents) is added. After stirring for 50 hours, the resulting mixture is concentrated *in vacuo*. The residue is dissolved in dichloromethane and an aqueous  $\text{NaHCO}_3$  solution is added. The dichloromethane layer is collected, dried over  $\text{Na}_2\text{SO}_4$ , filtered and concentrated *in vacuo*. The residue is further purified by column chromatography (gradient: dichloromethane => dichloromethane/methanol = 99/1 (v/v), silicagel) to give N-(1-cyclohexyl)-2-(2,4-dichlorophenyl)-5-methyl-1-(4-methoxyphenyl)-1H-imidazole-4-carboxamide (1.03 gram, 85 % yield). Melting point: 160-161 °C.

Analogously were prepared:

50. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-N,N,5-trimethyl-1H-imidazole-4-carboxamide. Melting point: 101-104 °C.

51. 1-(4-Chloropyridin-2-yl)-2-(2,4-dichlorophenyl)-5-methyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. MS: 464 ( $\text{MH}^+$ ).

52. 1-(4-Chloropyridin-2-yl)-2-(2,4-dichlorophenyl)-5-methyl-N-(4-morpholinyl)-1H-imidazole-4-carboxamide. MS: 466 (MH<sup>+</sup>).
53. N-(1-Azepanyl)-1-(4-Chloropyridin-2-yl)-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxamide. MS: 478 (MH<sup>+</sup>).
- 5 54. 1-(4-Chloropyridin-2-yl)-N-cyclohexyl-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxamide. MS: 463.
55. 1-(4-Chloropyridin-2-yl)-2-(2,4-dichlorophenyl)-5-methyl-N-(n-pentyl)-1H-imidazole-4-carboxamide. MS: 451.
56. 1-(4-Chloropyridin-2-yl)-2-(2,4-dichlorophenyl)-N-(4-fluorobenzyl)-5-methyl-1H-imidazole-4-carboxamide. MS: 489. Melting point: 123-126 °C.
- 10 57. 1-(4-Chlorophenyl)-N-cyclohexyl-5-methyl-2-(2-trifluoromethyl-4-chlorophenyl)-1H-imidazole-4-carboxamide. Melting point: 212 °C.
58. 1-(4-Chlorophenyl)-5-methyl-N-(piperidin-1-yl)-2-(2-trifluoromethyl-4-chlorophenyl)-1H-imidazole-4-carboxamide. Melting point: 165 °C.
- 15 59. 1-(4-Chlorophenyl)-2-(2-methoxy-4-chlorophenyl)-5-methyl-N-(n-pentyl)-1H-imidazole-4-carboxamide. Melting point: 131 °C.
60. 1-(4-Chlorophenyl)-2-(2-methoxy-4-chlorophenyl)-5-methyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: > 256 °C.
61. N-Cyclohexyl-1-(4-chlorophenyl)-2-(2-methoxy-4-chlorophenyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 201 °C.
- 20 62. 2-(2,4-Dichlorophenyl)-1-(4-fluorophenyl)-5-methyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 223-224 °C.
63. 2-(2,4-Dichlorophenyl)-5-methyl-1-(4-methoxyphenyl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: > 90 °C (decomposition).
- 25 64. N-Cyclohexyl-1-(4-fluorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 229-230 °C.
65. 1-(4-Chlorophenyl)-5-methyl-N-(n-pentyl)-2-(2-trifluoromethyl-4-chlorophenyl)-1H-imidazole-4-carboxamide. Amorphous.
66. 1-(4-Chlorophenyl)-2-(2-fluoro-4-chlorophenyl)-5-methyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 195 °C.
- 30 67. 1-(4-Chlorophenyl)-2-(2-fluoro-4-chlorophenyl)-5-methyl-N-(n-pentyl)-1H-imidazole-4-carboxamide. Melting point: 115 °C.
68. 1-(4-Chlorophenyl)-N-(cyclohexyl)-2-(2-fluoro-4-chlorophenyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 188 °C.
- 35 69. 1-(4-Chlorophenyl)-N-(cyclohexyl)-2-(1,5-dimethyl-1H-pyrrol-2-yl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 188-189 °C.
70. 1-(4-Chlorophenyl)-2-(1,5-dimethyl-1H-pyrrol-2-yl)-5-methyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 208-210 °C.
71. 2-(2-Chlorophenyl)-1-(3-fluorophenyl)-5-methyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 236-238 °C.
- 40 72. 2-(2-Chlorophenyl)-1-(3-fluorophenyl)-5-methyl-N-(n-pentyl)-1H-imidazole-4-carboxamide. Melting point: 97-102 °C.

73. 2-(2-Chlorophenyl)-N-cyclohexyl-1-(3-fluorophenyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 180-182.5 °C.
74. 2-(2-Chlorophenyl)-1-(3-fluorophenyl)-N-(2-(4-fluorophenyl)ethyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 123.5-126 °C.
- 5 75. 1-(4-Chloropyridin-2-yl)-2-(2,4-dichlorophenyl)-5-ethyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 146 °C.
76. 1-(4-Chloropyridin-2-yl)-2-(2,4-dichlorophenyl)-5-ethyl-N-(4-morpholinyl)-1H-imidazole-4-carboxamide. Melting point: 223 °C.
- 10 77. N-(1-Azepanyl)-1-(4-Chloropyridin-2-yl)-2-(2,4-dichlorophenyl)-5-ethyl-1H-imidazole-4-carboxamide. Melting point: 177 °C.
78. 1-(4-Chloropyridin-2-yl)-N-cyclohexyl-2-(2,4-dichlorophenyl)-5-ethyl-1H-imidazole-4-carboxamide. Melting point: 149 °C.
79. 1-(4-Chloropyridin-2-yl)-2-(2,4-dichlorophenyl)-5-ethyl-N-(n-pentyl)-1H-imidazole-4-carboxamide. Melting point: Oil.
- 15 80. 1-(4-Chloropyridin-2-yl)-2-(2,4-dichlorophenyl)-5-ethyl-N-(4-fluorophenylmethyl)-1H-imidazole-4-carboxamide. MP: amorphous.
81. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-N-(hexahydrocyclopenta-[c]pyrrol-2(1H)-yl)-5-methyl-1H-imidazole-4-carboxamide. MP: 143-146 °C.
82. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-N-phenyl-1H-imidazole-4-carboxamide. Melting point: 91-95 °C.
- 20 83. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-N-(tetrahydro-2H-pyran-2-yloxy)-1H-imidazole-4-carboxamide. Melting point: 128-133 °C.
84. N-(Exo-bicyclo[2.2.1]hept-2-yl)-1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 194-195 °C.
- 25 85. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-N-(2-fluoroethyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 128-133 °C.
86. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-N-(trans-4-hydroxycyclohexyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 160 °C (dec.).
87. 1-([1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazol-4-yl]carbonyl)-4-hydroxypiperidine. Melting point: Amorphous.
- 30 88. 1-([1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazol-4-yl]carbonyl)-1,2,3,4-tetrahydroisoquinoline. Melting point: 143-146 °C.
89. N-(Endo-bicyclo[2.2.1]hept-2-yl)-1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 194-195 °C.
- 35 90. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-N-(4-fluorobenzyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 165-166 °C.
91. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-N-(n-pentyl)-1H-imidazole-4-carboxamide. Oil.
92. N-(Azepan-1-yl)-1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 147-149 °C.
- 40 93. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-N-(pyrrolidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 205-206 °C.

94. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-N-(morpholin-4-yl)-1H-imidazole-4-carboxamide. Melting point: 225 °C (dec.).
95. 2-(2,5-Dichlorophenyl)-5-methyl-1-phenyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 227 °C.
- 5 96. N-Cyclohexyl-2-(2,5-dichlorophenyl)-5-methyl-1-phenyl-1H-imidazole-4-carboxamide. Melting point: 236 °C.
97. N-Cyclohexyl-2-(2,4-dichlorophenyl)-1-(2,5-difluorophenyl)-5-ethyl-1H-imidazole-4-carboxamide. Melting point: 144-146 °C.
- 10 98. N-Cyclohexyl-2-(2,4-dichlorophenyl)-1-(2,5-difluorophenyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 206-208 °C.
99. N-Cyclohexyl-2-(1,5-dimethyl-1H-pyrrol-2-yl)-5-ethyl-1-phenyl-1H-imidazole-4-carboxamide. Melting point: 195-196 °C.
100. N-Cyclohexyl-2-(2,5-dichlorophenyl)-5-ethyl-1-phenyl-1H-imidazole-4-carboxamide. Melting point: 198-199 °C.
- 15 101. 2-(2,5-Dichlorophenyl)-5-ethyl-1-phenyl-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 207-208 °C.
102. 1-(4-Chlorophenyl)-5-methyl-2-(3-methylpyridin-2-yl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 211-213 °C.
103. 1-(4-Chlorophenyl)-N-cyclohexyl-5-methyl-2-(3-methylpyridin-2-yl)-1H-imidazole-4-carboxamide. Melting point: 188-190 °C.
- 20 104. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-N-(3-(trifluoromethyl)phenyl)-1H-imidazole-4-carboxamide. Melting point: 177 °C.
105. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-N-(3-(trifluoromethyl)benzyl)-1H-imidazole-4-carboxamide. Melting point: 138-140 °C.
- 25 106. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-N-(4-(trifluoromethyl)benzyl)-1H-imidazole-4-carboxamide. Melting point: 232 °C.
107. 1-(4-Chlorophenyl)-N-cyclopentyl-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 172 °C.
108. 1-(4-Chlorophenyl)-N-cycloheptyl-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxamide. Melting point: 154-156 °C.
- 30

#### Example 109

**Part A:** Ethyl 1-(4-bromophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate is converted to ethyl 1-(4-bromophenyl)-5-chloro-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate analogously to a published procedure (N. Kudo et al., *Chem. Pharm. Bull.* **1999**, *47*, 857-868) using excess of SO<sub>2</sub>Cl<sub>2</sub> in dichloroethane at reflux temperature for 50 hours.

35

**Part B:** Ethyl 1-(4-bromophenyl)-5-chloro-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate is converted to 1-(4-bromophenyl)-5-chloro-2-(2,4-dichlorophenyl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide (melting point: > 150 °C; R<sub>f</sub> (Silicagel, EtOAc) ~ 0.35) analogously to the procedure described in example 22 above. <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>): δ 7.85 (br s, 1H), 7.52 (dt, J = 8 Hz, J = 2 Hz, 2H), 7.26-7.36

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(m, 3H), 7.01 (dt, J = 8 Hz, J = 2 Hz, 2H), 2.85-2.92 (m, 4H), 1.72-1.80 (m, 4H), 1.40 – 1.44 (m, 2H).

#### Example 110

5 **Part A:** To a stirred solution of 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylic acid (18.38 gram, 50 mmol) in toluene (200 mL) in a nitrogen atmosphere is added N,N-dimethylformamide di-tert-butyl acetal (50 mL) and the resulting mixture is heated at 80 °C for 4 hours. After cooling to room temperature the reaction mixture is concentrated and diethyl ether is added. The resulting solution is  
10 twice washed with water, dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo*. The residue is crystallised from diisopropyl ether to give pure tert-butyl 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate (10.35 gram, 49 % yield). Melting point: 179-181 °C.

#### Part B:

15 Lithium diisopropyl amide (LDA) (5.25 mL of a 2 M solution in THF, 0.0105 mol) is added dropwise to a cooled solution (-70 °C) of tert-butyl 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate (4.24 gram, 0.010 mol) in anhydrous THF (80 mL) in a nitrogen atmosphere and the resulting mixture is stirred for one hour. A solution of p-toluenesulfonyl cyanide (1.88 gram, 0.011 mol) in anhydrous  
20 THF (20 mL) is added dropwise and the resulting red solution is stirred for one hour at - 70 °C and then allowed to attain room temperature. Diethyl ether is added and the resulting solution is quenched with water and filtered over hyflo. The organic layer is collected and washed with water, dried over MgSO<sub>4</sub>, filtered and concentrated *in vacuo* to give an oil. This oil is purified by column chromatography (dichloromethane,  
25 silicagel) to give 3.4 gram of tert-butyl 1-(4-chlorophenyl)-5-cyano-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate. Recrystallisation from diisopropyl ether gave crystalline tert-butyl 1-(4-chlorophenyl)-5-cyano-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylate (2.57 gram, 57 % yield). Melting point: 210-212 °C.

30 Analogously was prepared:

- Tert-butyl 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-5-methyl-1H-imidazole-4-carboxylate. <sup>1</sup>H-NMR (400 MHz, CDCl<sub>3</sub>): δ 7.38 (d, J = 8 Hz, 1H), 7.34 (dt, J = 8 Hz, J = 2 Hz, 2H), 7.27 (d, J = 2 Hz, 1H), 7.22 (dd, J = 8 Hz, J = 2 Hz, 1H), 7.03 (dt, J = 8 Hz, J = 2 Hz, 2H), 2.40 (s, 3H), 1.63 (s, 9H).

#### Part C:

To a solution of tert-butyl 1-(4-chlorophenyl)-2-(2,4-dichlorophenyl)-5-cyano-1H-imidazole-4-carboxylate (2.57 gram, 5.73 mmol) in dichloromethane (40 mL) is added trifluoroacetic acid and the resulting solution is stirred at room temperature for 20  
40 hours and concentrated *in vacuo*. The residue is crystallised from diisopropyl ether to give pure 1-(4-chlorophenyl)-5-cyano-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylic acid (1.95 gram, 87 % yield). Melting point: 200-202 °C (dec.).

**Part D:**

1-(4-Chlorophenyl)-5-cyano-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxylic acid is converted to 1-(4-chlorophenyl)-5-cyano-2-(2,4-dichlorophenyl)-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide in 60 % yield, analogously to the procedure described in example 22, part B herein above. Melting point: 231-233.5 °C.

Analogously were prepared:

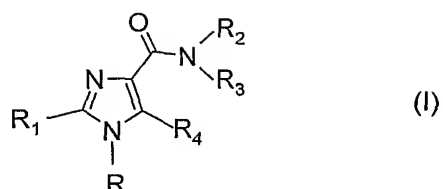
111. 1-(4-Chlorophenyl)-2-(2,4-dichlorophenyl)-5-iodo-N-(piperidin-1-yl)-1H-imidazole-4-carboxamide. Melting point: 196-201 °C.

112. 1-(4-Chlorophenyl)-N-cyclohexyl-2-(2,4-dichlorophenyl)-5-iodo-1H-imidazole-4-carboxamide. Melting point: 226-230 °C.

113. 1-(4-Chlorophenyl)-5-cyano-N-cyclohexyl-2-(2,4-dichlorophenyl)-1H-imidazole-4-carboxamide. Melting point: 157-158 °C.

**Claims**

1. A compound of formula (I)



wherein

- R represents phenyl, thienyl, 2-pyridinyl, 3-pyridinyl, 4-pyridinyl, pyrimidinyl, pyrazinyl, pyridazinyl or triazinyl, which groups may be substituted with 1, 2, 3 or 4 substituents Y, which can be the same or different, from the group C<sub>1-3</sub>-alkyl or alkoxy, hydroxy, halogen, trifluoromethyl, trifluoromethylthio, trifluoromethoxy, nitro, amino, mono- or dialkyl (C<sub>1-2</sub>)-amino, mono- or dialkyl (C<sub>1-2</sub>)-amido, (C<sub>1-3</sub>)-alkoxycarbonyl, carboxyl, cyano, carbamoyl and acetyl, or R represents naphthyl, with the proviso that when R is 4-pyridinyl, R<sub>4</sub> represents a halogen atom or a cyano, carbamoyl, formyl, acetyl, trifluoroacetyl, fluoroacetyl, propionyl, sulfamoyl, methanesulfonyl, methylsulfonyl or branched or unbranched C<sub>1-4</sub> alkyl group, which C<sub>1-4</sub> alkyl group may be substituted with 1-3 fluoro atoms or with a bromo, chloro, iodo, cyano or hydroxy group,
- R<sub>1</sub> represents phenyl or pyridinyl, which groups may be substituted with 1-4 substituents Y, which can be the same or different, wherein Y has the above mentioned meaning, or R<sub>1</sub> represents pyrimidinyl, pyrazinyl, pyridazinyl or triazinyl, which groups may be substituted with 1-2 substituents Y, which can be the same or different or R<sub>1</sub> represents a five-membered aromatic heterocyclic ring having one or two heteroatoms from the group (N, O, S), which heteroatoms can be the same or different, which five-membered aromatic heterocyclic ring may be substituted with 1-2 substituents Y, which can be the same or different or R<sub>1</sub> represents naphthyl,
- R<sub>2</sub> represents H, branched or unbranched C<sub>1-8</sub> alkyl, C<sub>3-8</sub> cycloalkyl, C<sub>3-8</sub> alkenyl, C<sub>5-8</sub> cycloalkenyl which groups may contain a sulfur, oxygen or nitrogen atom,
- R<sub>3</sub> represents branched or unbranched C<sub>2-8</sub> alkyl, C<sub>1-8</sub> alkoxy, C<sub>5-8</sub> cycloalkyloxy, C<sub>3-8</sub> cycloalkyl, C<sub>5-10</sub> bicycloalkyl, C<sub>6-10</sub> tricycloalkyl, C<sub>3-8</sub> alkenyl, C<sub>5-8</sub> cycloalkenyl, which groups may optionally contain one or more heteroatoms from the group (O, N, S) and which groups may be substituted with a hydroxy group or 1-2 C<sub>1-3</sub> alkyl groups or 1-3 fluoro atoms, or R<sub>3</sub> represents a benzyl or phenethyl group which aromatic rings may be substituted with 1-5 substituents Z, which can be the same or different, from the group C<sub>1-3</sub>-alkyl or alkoxy, hydroxy, halogen, trifluoromethyl, trifluoromethylthio, trifluoromethoxy, nitro, amino, mono- or dialkyl (C<sub>1-2</sub>)-amino, mono- or dialkyl (C<sub>1-2</sub>)-amido, (C<sub>1-3</sub>)-alkylsulfonyl, dimethyl-sulfamido, C<sub>1-3</sub>-

alkoxycarbonyl, carboxyl, trifluoromethylsulfonyl, cyano, carbamoyl, sulfamoyl and acetyl, or  $R_3$  represents a phenyl or pyridinyl group, which groups are substituted with 1-4 substituents Z, wherein Z has the meaning as indicated above,

5 or  $R_3$  represents a pyridinyl group, or  $R_3$  represents a phenyl group, with the proviso that  $R_4$  represents a halogen atom or a cyano, carbamoyl, formyl, acetyl, trifluoroacetyl, fluoroacetyl, propionyl, sulfamoyl methanesulfonyl, methylsulfanyl or  $C_{1-4}$  alkyl group, which  $C_{1-4}$  alkyl group may be substituted with 1-3 fluoro atoms or with a bromo, chloro, iodo, cyano or hydroxy group,

10 or  $R_3$  represents a group  $NR_5R_6$  with the proviso that  $R_2$  represents a hydrogen atom or a methyl group, wherein

- $R_5$  and  $R_6$  are the same or different and represent branched or unbranched  $C_{1-4}$  alkyl, or  $R_5$  and  $R_6$  - together with the nitrogen atom to which they are bonded - form a saturated or unsaturated, monocyclic or bicyclic heterocyclic group having 4 to 10 ring atoms which heterocyclic group contains one or two heteroatoms from the group (N, O, S), which heteroatoms can be the same or different, which heterocyclic group may be substituted with a  $C_{1-3}$  alkyl group or a hydroxy group,

15 or  $R_2$  and  $R_3$  - together with the nitrogen atom to which they are bonded - form a saturated or unsaturated heterocyclic group having 4 to 10 ring atoms which heterocyclic group contains one or two heteroatoms from the group (N, O, S), which heteroatoms can be the same or different, which heterocyclic group may be substituted with a  $C_{1-3}$  alkyl group or a hydroxy group,

- $R_4$  represents a hydrogen or halogen atom or a cyano, carbamoyl, formyl, acetyl, trifluoroacetyl, fluoroacetyl, propionyl, sulfamoyl, methanesulfonyl, methylsulfanyl or branched or unbranched  $C_{1-4}$  alkyl group, which  $C_{1-4}$  alkyl group may be substituted with 1-3 fluoro atoms or with a bromo, chloro, iodo, cyano or a hydroxy group,

20 and prodrugs, stereoisomers and salts thereof.

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2. Pharmaceutical compositions containing a pharmacologically active amount of at least one compound as claimed in 1 as an active component.

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3. Method of preparing pharmaceutical compositions as claimed in claim 2 characterised in that a compound as claimed in claim 1 is brought in a form suitable for administration.

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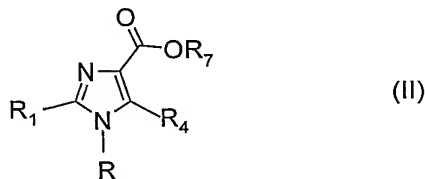
4. Process for the preparation of compounds having formula (I), characterised in that a compound is prepared wherein R,  $R_1$ - $R_3$  have the meanings given in claim 1 and  $R_4$  represents a hydrogen or halogen atom or a cyano, carbamoyl, formyl, acetyl, trifluoroacetyl, propionyl, sulfamoyl, methanesulfonyl, methylsulfanyl or  $C_{1-4}$  alkyl group, which  $C_{1-4}$  alkyl group may be substituted with 1-3 fluoro atoms,



by reacting a compound having formula (II), (III) or (IV) with a compound of formula  $R_2R_3NH$ .

5. Process for the preparation of compounds having formula (II)

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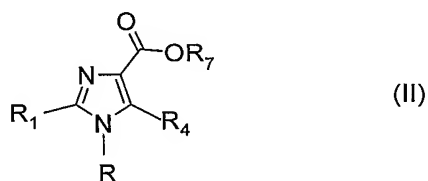
wherein  $R_4$  represents a  $C_{1-4}$  alkyl group, which  $C_{1-4}$  alkyl group may be substituted with 1-3 fluoro substituents, or wherein  $R_4$  represents a halogen atom or a cyano, formyl, acetyl, trifluoroacetyl, fluoroacetyl, methylsulfanyl or propionyl group, characterized in that a compound is prepared wherein R and  $R_1$  have the meanings given in claim 1 and  $R_7$  represents a branched or unbranched alkyl group ( $C_{1-4}$ ) or benzyl group, by reacting a compound having formula (II) wherein  $R_4$  is a hydrogen atom with a compound having formula  $R_4'-X$ , wherein X represents a leaving group and  $R_4'$  represents a  $C_{1-4}$  alkyl group, which  $C_{1-4}$  alkyl group may be substituted with 1-3 fluoro substituents, or wherein  $R_4'$  represents a halogen atom or a cyano, formyl, acetyl, trifluoroacetyl, fluoroacetyl, methylsulfanyl or propionyl group, in the presence of a strong non-nucleophilic base.

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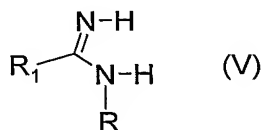
6. Process for the preparation of a compound having formula (II)



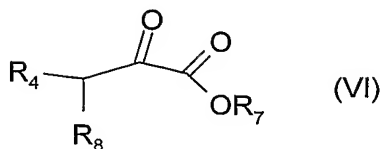
wherein  $R_4$  represents a branched or unbranched  $C_{1-4}$  alkyl group, which  $C_{1-4}$  alkyl group may be substituted with 1-3 fluoro substituents, characterized in that a compound is prepared wherein R,  $R_1$  have the meanings given in claim 1 and  $R_7$  represents a branched or unbranched alkyl group ( $C_{1-4}$ ) or benzyl group, by reacting a compound having formula (V) or its tautomer

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wherein R and R<sub>1</sub> have the meanings given in claim 1, with a compound having formula (VI)

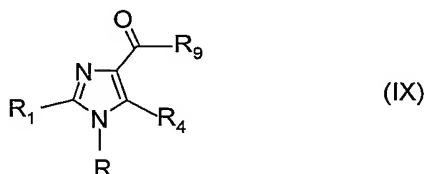


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wherein R<sub>4</sub> represents a branched or unbranched C<sub>1-4</sub> alkyl group, which C<sub>1-4</sub> alkyl group may be substituted with 1-3 fluoro atoms and R<sub>8</sub> represents a so-called leaving group and R<sub>7</sub> represents a branched or unbranched alkyl group (C<sub>1-4</sub>) or benzyl group.

10

#### 7. Compounds of formula (IX)



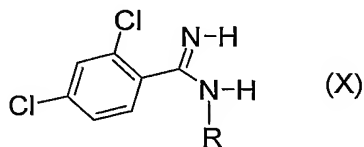
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wherein R and R<sub>4</sub> have the meanings given in claim 1 and wherein R<sub>1</sub> represents a phenyl or pyridinyl group, which groups are substituted with 1-4 substituents Y, which can be the same or different, or R<sub>1</sub> represents a pyrimidinyl, pyrazinyl, pyridazinyl or triazinyl group, which groups are substituted with 1-2 substituents Y, which can be the same or different or R<sub>1</sub> represents a five-membered aromatic heterocyclic moiety having one or two heteroatoms from the group (N, O, S), which heteroatoms can be the same or different, which five-membered aromatic heterocyclic moiety may be substituted with 1-2 substituents Y, which can be the same or different or R<sub>1</sub> represents naphthyl and R<sub>9</sub> represents a hydroxy group, a branched or unbranched alkoxy (C<sub>1-4</sub>) group, a benzyloxy group or a chloro substituent.

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#### 8. Compounds of formula (X) and tautomers thereof



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wherein R represents a 4-chlorophenyl group, a 4-bromophenyl group or a 4-(trifluoromethyl)phenyl group.

9. Use of a compound as claimed in claim 1 for the preparation of a pharmaceutical composition for the treatment of disorders involving cannabinoid neurotransmission.

5

10. Use as claimed in claim 9 characterised in that said disorders are psychiatric disorders such as psychosis, anxiety, depression, attention deficits, memory disorders, cognitive disorders, appetite disorders, obesity, addiction, appetence, drug dependence and neurological disorders such as neurodegenerative disorders, dementia, dystonia, muscle spasticity, tremor, epilepsy, multiple sclerosis, traumatic brain injury, stroke, Parkinson's disease, Alzheimer's disease, epilepsy, Huntington's disease, Tourette's syndrome, cerebral ischaemia, cerebral apoplexy, craniocerebral trauma, stroke, spinal cord injury, neuroinflammatory disorders, plaque sclerosis, viral encephalitis, demyelination related disorders, as well as for the treatment of pain disorders, including neuropathic pain disorders, and other diseases involving cannabinoid neurotransmission, including the treatment of septic shock, glaucoma, cancer, diabetes, emesis, nausea, asthma, respiratory diseases, gastrointestinal disorders, gastric ulcers, diarrhoea and cardiovascular disorders.

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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU,  
AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU,  
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LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW,  
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TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,  
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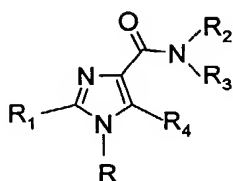
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For two-letter codes and other abbreviations, refer to the "Guid-  
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ning of each regular issue of the PCT Gazette.

(54) Title: 1H-IMIDAZOLE DERIVATIVES HAVING CB<sub>1</sub> AGONISTIC, CB<sub>1</sub> PARTIAL AGONISTIC OR CB<sub>1</sub>- ANTAGONIS-  
TIC ACTIVITY



(I)

(57) Abstract: AbstractThe present invention relates to a group of novel 1H-imidazole derivatives, to methods for the preparation of these compounds, and to pharmaceutical compositions containing one or more of these compounds as an active component. These 1H-imidazole derivatives are potent cannabinoid-CB<sub>1</sub> receptor agonists, partial agonists or antagonists, useful for the treatment of psychiatric and neurological disorders, as well as and other diseases involving cannabinoid neurotransmission. The compounds have the general formula (I) wherein R and R<sub>1</sub>-R<sub>4</sub> have the meanings given in the specification.

# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/EP 02/10434

## A. CLASSIFICATION OF SUBJECT MATTER

IPC 7 A61K31/4164 C07D233/90 C07C257/18 C07D401/04 C07D403/04  
C07D405/12 C07D403/12

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 C07D C07C A61K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

BEILSTEIN Data, WPI Data, PAJ, CHEM ABS Data, EPO-Internal

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	CHEMICAL ABSTRACTS, vol. 133, no. 18, 30 October 2000 (2000-10-30) Columbus, Ohio, US; abstract no. 252124, LI, ZHI FANG ET AL: "Facile synthesis of amidines via intermolecular reductive coupling of nitriles with azobenzene promoted by samarium diiodide" XP002186058 see compound wherein R is 2,4-diClPh abstract & CHIN. CHEM. LETT. (2000), 11(6), 495-498,  --- -/--	6,8

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the International filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the International filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \* & \* document member of the same patent family

Date of the actual completion of the international search

4 December 2002

Date of mailing of the international search report

11/12/2002

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## INTERNATIONAL SEARCH REPORT

International Application No  
PCT/EP 02/10434

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	TAISEI UEDA ET AL: "A novel ring transformation of 5-Acylaminouracils" TETRAHEDRON LETTERS, vol. 29, no. 36, 1988, pages 4607-4610, XP001038533 see Compound 3e ---	1
A	NORIAKI KUDO ET AL: "Synthesis and Herbicidal activity of 1,5-Diarylpyrazole derivatives" CHEM PHARM BULL, vol. 47, no. 6, 1999, pages 857-868, XP001026111 cited in the application Y see compounds 7,8,29a,29b	1  7
A	--- KHANNA I K ET AL: "1,2-DIARYLIMIDAZOLES AS POTENT, CYCLOOXYGENASE-2 SELECTIVE, AND ORALLY ACTIVE ANTIINFLAMMATORY AGENTS" JOURNAL OF MEDICINAL CHEMISTRY, AMERICAN CHEMICAL SOCIETY. WASHINGTON, US, vol. 40, 1997, pages 1634-1647, XP000941303 ISSN: 0022-2623 cited in the application see table 7 ---	1-10
Y	ISH KHANNA ET AL: "Selective Cyclooxygenase 2-Inhibitors" JOURNAL OF MEDICINAL CHEMISTRY, vol. 43, no. 16, 2000, pages 3168-3185, XP001026112 cited in the application See Scheme 9 ---	4-8
Y	PERTWEE R G: "PHARMACOLOGY OF CANNABINOID RECEPTOR LIGANDS" CURRENT MEDICINAL CHEMISTRY, BENTHAM SCIENCE PUBLISHERS BV, BE, vol. 6, no. 8, August 1999 (1999-08), pages 635-664, XP000923352 ISSN: 0929-8673 see compounds on page 641 and pages 657-659 ---	1-10
Y	US 5 616 601 A (KHANNA ISH ET AL) 1 April 1997 (1997-04-01) see especially formula 4, column 22 ---	7
A	WO 00 63204 A (NOVARTIS ERFIND VERWALT GMBH ;NOVARTIS AG (CH); REVESZ LASZLO (CH)) 26 October 2000 (2000-10-26) the whole document --- -/--	1-10

## INTERNATIONAL SEARCH REPORT

International Application No  
PCT/EP 02/10434

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 00 46209 A (SANOFI SYNTHELABO ; BARTH FRANCIS (FR); CAMUS PHILIPPE (FR); MARTIN) 10 August 2000 (2000-08-10) the whole document ----	1-10
Y	THOMAS ET AL: "Comparative receptor binding analyses of cannabinoid agonists and antagonists" J PHARMACOL. EXP THER, vol. 285, no. 1, 1998, pages 285-292, XP000942485 see whole document -----	1-10

## INTERNATIONAL SEARCH REPORT

International application No.  
PCT/EP 02/10434

### Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This International Search Report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☒ Claims Nos.: 1-3, 9, 10  
because they relate to parts of the International Application that do not comply with the prescribed requirements to such an extent that no meaningful International Search can be carried out, specifically:  
see FURTHER INFORMATION sheet PCT/ISA/210
3. ☐ Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

### Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this International Search Report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this International Search Report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this International Search Report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

#### Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest.
- ☐ No protest accompanied the payment of additional search fees.



**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

Continuation of Box I.2

Claims Nos.: 1-3,9,10

Present claims 1-3,9,10 relate to a compound or use defined by reference to a desirable characteristic or property, namely that it be a prodrug of the formula I compounds.

The claims cover all compounds and uses having this characteristic or property, whereas the application provides support within the meaning of Article 6 PCT and/or disclosure within the meaning of Article 5 PCT for only a very limited number of such compounds and uses. In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible. Independent of the above reasoning, the claims also lack clarity (Article 6 PCT). An attempt is made to define the product by reference to a result to be achieved. Again, this lack of clarity in the present case is such as to render a meaningful search over the whole of the claimed scope impossible. Consequently, the search has been carried out for those parts of the claims which appear to be clear, supported and disclosed, namely those parts relating to the compounds of formula I and their use, and not their prodrugs.

The applicant's attention is drawn to the fact that claims, or parts of claims, relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No  
PCT/EP 02/10434

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 5616601	A	01-04-1997	AT 224374 T	15-10-2002
			AU 3202595 A	22-02-1996
			CA 2195845 A1	08-02-1996
			DE 69528273 D1	24-10-2002
			EP 0772600 A1	14-05-1997
			JP 10503211 T	24-03-1998
			WO 9603388 A1	08-02-1996
WO 0063204	A	26-10-2000	AU 4295300 A	02-11-2000
			BR 0010598 A	05-02-2002
			CN 1378544 T	06-11-2002
			CZ 20013696 A3	13-02-2002
			WO 0063204 A2	26-10-2000
			EP 1224180 A2	24-07-2002
			NO 20014987 A	14-12-2001
			SK 14562001 A3	05-03-2002
			TR 200102967 T2	21-01-2002
			US 2002049220 A1	25-04-2002
WO 0046209	A	10-08-2000	FR 2789078 A1	04-08-2000
			FR 2789079 A1	04-08-2000
			AU 2298900 A	25-08-2000
			BG 105749 A	28-02-2002
			BR 0007895 A	30-10-2001
			CN 1346349 T	24-04-2002
			CZ 20012697 A3	17-10-2001
			EE 200100399 A	15-10-2002
			EP 1150961 A1	07-11-2001
			WO 0046209 A1	10-08-2000
			HR 20010564 A1	31-08-2002
			JP 2002536366 T	29-10-2002
			NO 20013736 A	28-09-2001
			NZ 512886 A	25-10-2002
			PL 350030 A1	21-10-2002
			SK 10872001 A3	03-12-2001
			TR 200102054 T2	21-05-2002
			US 6432984 B1	13-08-2002